The Luminosity Function of 24 Abell Clusters from the CRoNaRio catalogues

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ABSTRACT. We present the composite luminosity function of galaxies for 24 Abell clusters studied in our survey of the Northern Hemisphere, using DPOSS data in the framework of the CRoNaRio collaboration. Our determination of the luminosity function has been computed with very high accuracy thanks to 1) the use of homogeneous data both in the cluster and in the control field, 2) a local estimate of the background, which takes into account the presence of large-scale structures (which tipically make the background contribution larger) and of foreground clusters and groups; 3) the inclusion in the error calculation of the variance of background counts, which is tipically larger than Poissonian fluctuation. We plan at least a tenfold increase of the number of clusters.

1. The CRoNaRio Project (**C**altech-**Ro**ma-**Na**poli-**Rio** de Janeiro)

The CRoNaRio Project is a joint enterprise among Caltech and the astonomical observatories of Napoli, Roma and Rio de Janeiro, aimed to produce the first general catalogue of all the objects visible on the DPOSS (Digitised Palomar Sky Survey; Djorgovski et al., 1999). The final Palomar-Norris North Sky Catalogue will include astrometric, photometric (in the three Gunn-Thuan bands g,r and i) and rough morphological information for an estimated number of 2×10^9 stars and 5×10^7 galaxies.

2. The derivation of Luminosity Functions

The luminosity function (LF) of galaxy clusters is given by the statistical difference between galaxy counts in the cluster direction and those in an empty (i.e., not including clusters) field. Therefore, for an accurate computation of the cluster LF we need a good estimate of the background counts and a careful selection of the surveyed cluster area.

To this end, we take advantage of our wide sky coverage by merging the CRoNaRio g, r and i catalogues into a "matched catalogue" (see Puddu et al., this meeting, for more details), containing all those objects which are detected in at least two of the three bands, and by deriving a density map of galaxies in a 5×5 Mpc ($H_0 = 50$) region centered on the estimated cluster center. We then enhance galaxy fluctuations on cluster

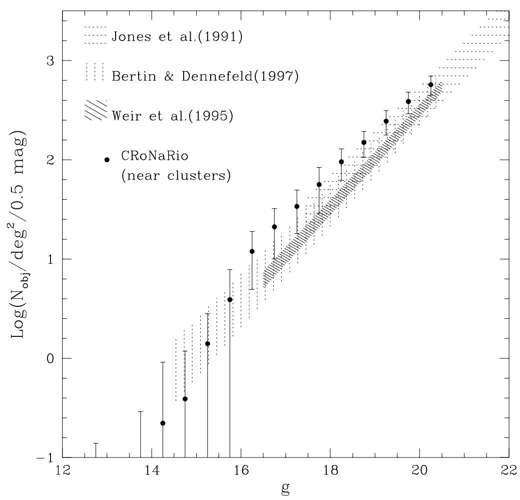

Fig. 1. Comparison of near-cluster background counts with some previous determinations.

scales convolving our map with a Gaussian function having width corresponding to 250 Kpc in the cluster rest–frame, *id est* to a tipical cluster core radius (Puddu et al.).

In order to estimate the background contribution we first excluded a 3 Mpc wide circular region centered on the cluster to avoid any unwanted contamination from cluster galaxies, and then derived the background galaxy counts and their *variance* over an angular scale comparable to that of the cluster.

Such a local correction is more accurate than the traditional average one for the following reasons:

1. a local background estimate allows to correct for the underlying large-scale structures. These structures are neglected if the average number counts for the field are used. As shown in Fig. 1, the background near (but not too near) to the cluster is usually much higher than the average.
2. since local fluctuations are larger than Poissonian errors, our measured variance correctly estimates the uncertainty introduced by a statistical background subtraction.
3. the use of homogeneous data, reduced in the same way, for both the background and the cluster galaxy counts, allows us to compensate for systematic errors due to selection effects, which cancel out (at least in large part) in the statistical subtraction of the counts.

To detect clusters independently from the center position listed in the Abell catalog, we searched for the central 1.5 σ density peak in the inner 3 Mpc circle and then we derived the cluster LF by subtracting, from the galaxy counts measured in this region, the background counts previously measured, rescaled to the cluster area. This approach makes it possible to apply the statistical background correction to the region having higher signal to noise ratio. Moreover, we estimated the completeness limit of

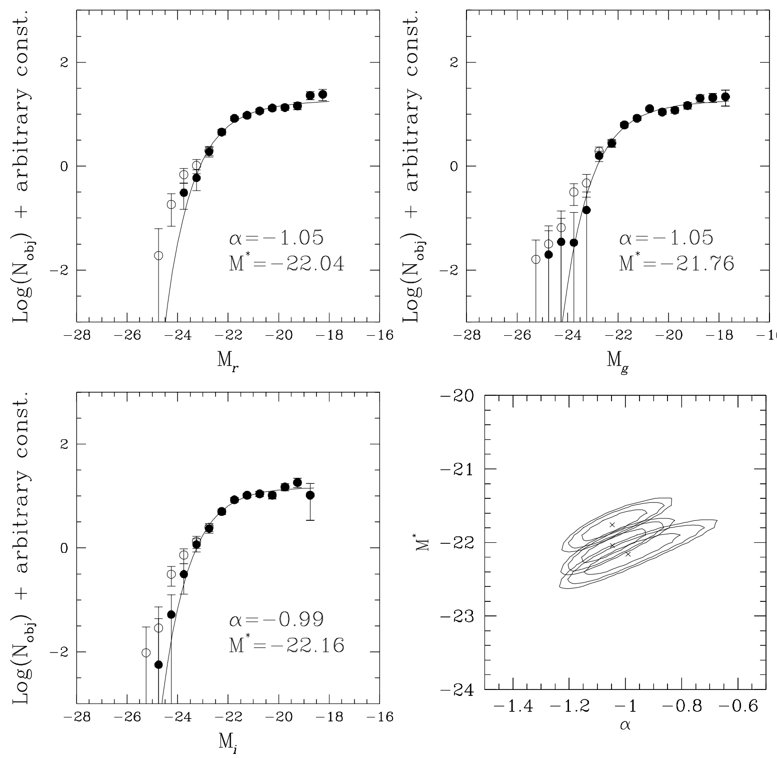

Fig. 2. The cumulative LF. Empty dots: brightest cluser member (BCM) incuded; filled dots: BCM excluded.

our data for each cluster independently, so to take into account the depth variations of our catalogs from plate to plate and as a function of the cluster location in the plate.

3. The cluster sample

As a first application of the method, we computed the luminosity function of 24 near ($z < 0.28$) and rich Abell clusters. Redshift were taken from the literature, paying attention to include in the sample only clusters with well measured redshift. The composite cluster LF were then cumulated following the Garilli et al. (1999) method. Figure 2 gives the composite LF and the best fitting Schechter (1976) function.

4. Discussion of the cumulative luminosity function

The LF is quite flat: its slope, at $M^* + 5$, is ~ 1.0 in the three filter. This slope matches well those found by Garilli et al. (1999), based on CCD data, who used a completely

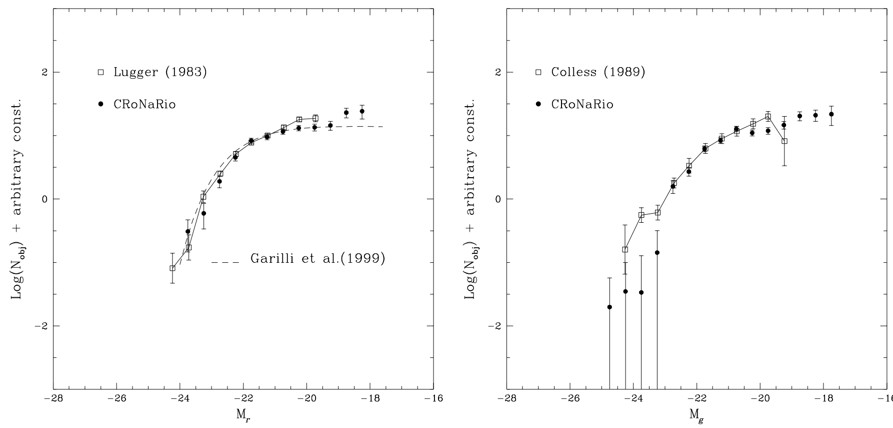

Fig. 3. Comparison between the cumulative LF and the LFs obtained by Lugger (1983) and Colless (1989) from photographic material, and Garilli et al. (1999) from CCD data.

different method for the background subtraction. The slope of the LF is flatter than what is traditionally found ($\alpha \sim -1.25$) from photographic plates by adopting an average background (e.g. Schechter 1976). Our shallower slope is due to the use of a local background, which is higher than the average background (see figure 1).

The LF color, obtained from the differences between M^* values computed in the three photometric bands, is similar to the colors of early-type galaxies (Fukugita et al., 1995; Garilli et al., 1999).

Figure 3 shows how our LF, based on the first 24 clusters of our survey, matches those available in the literature. It is important to notice that CRoNaRio data reach 1.5 magnitudes deeper than other works based on photographic material and are comparable to those obtained with CCDs.

The huge coverage of the DPOSS - the whole Northern Hemisphere - will allow us to produce the LF of at least a tenfold higher number of clusters with known redshift and to explore the dependence of the LF on the dinamical evolution, cluster richness and other environmental and morphological parameters.

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